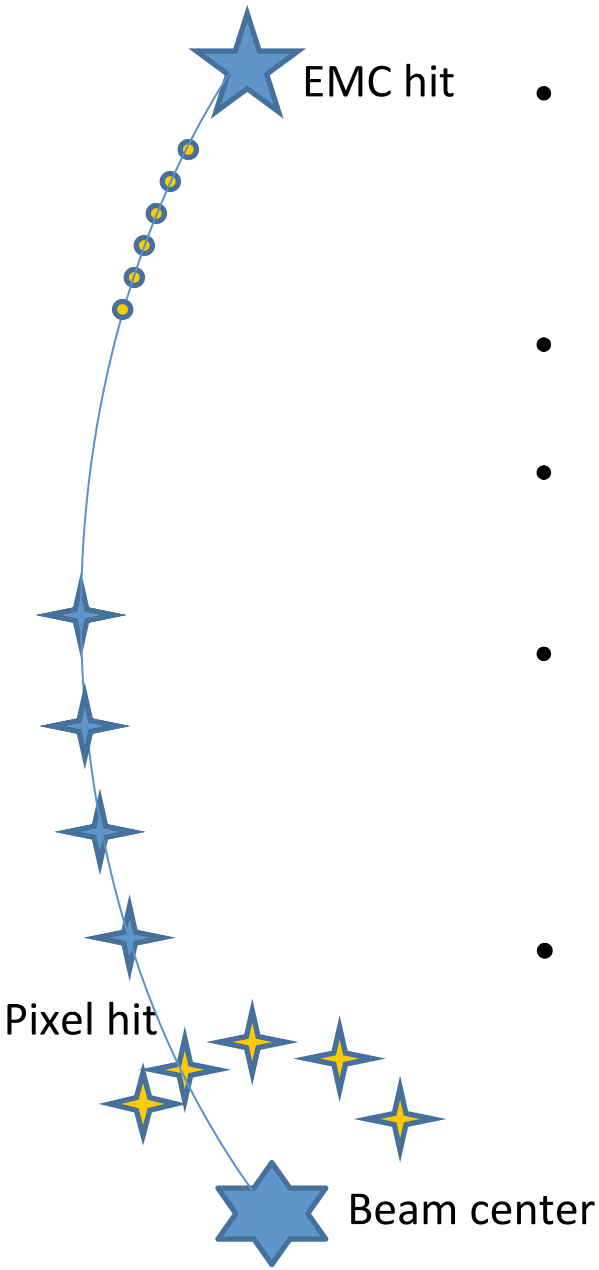
Pixel-strip-EMC tracker and DC option

Gaku Mitsuka (RBRC)
Yorito Yamaguchi (RBRC)
Itaru Nakagawa (RIKEN/RBRC)
Y. Akiba (RIKEN/RBRC)
Rachid Nouicer (BNL)

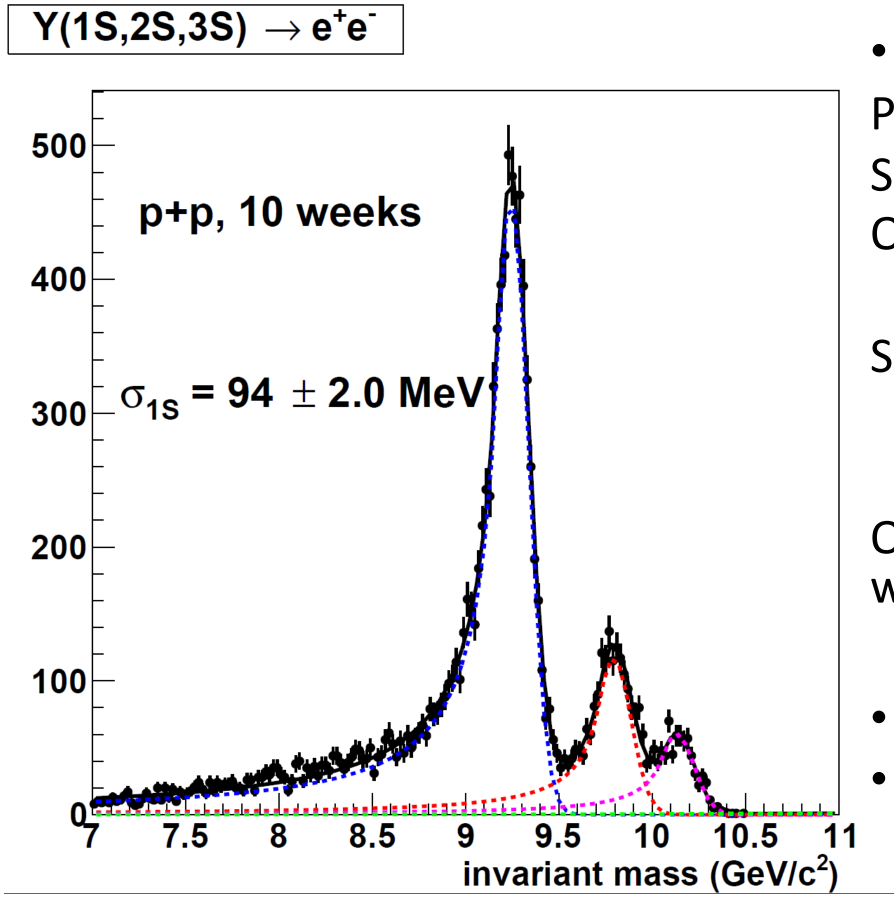
2016/06/24

The idea



- Reconstruct track by
  - 1 "pixel layer" (MAPS or VTXP)
  - 4 strips (80um x 12mm)
  - EMC hit
- Associate the track with a large radius outer-tracker just before EMC
- The track is reconstructed by the EMC-strip-pixel, and its momentum is refined by the outer tracker
- TPC is a good outer tracker for this purpose, but we believe that a Drift chamber (jet chamber) like PHENIX DC can also work.
  - If a DC works, it can save cost of the tracker substantially
- This is a minimum model. If this doesn't have sufficient performance, we can always increase the number of strip or pixel layers.

G4 simulation result (Upsilon)



- Gaku implemented a model o the idea in sPHENIX G4 simulation.
- The model:

Pixel	R=2.5cm	(1.3%X0)
Strips	R=6,8,10,12	(1%X0 per layer)
Outer	R=77.5,79,80.5,82.0,83.5,85.0	

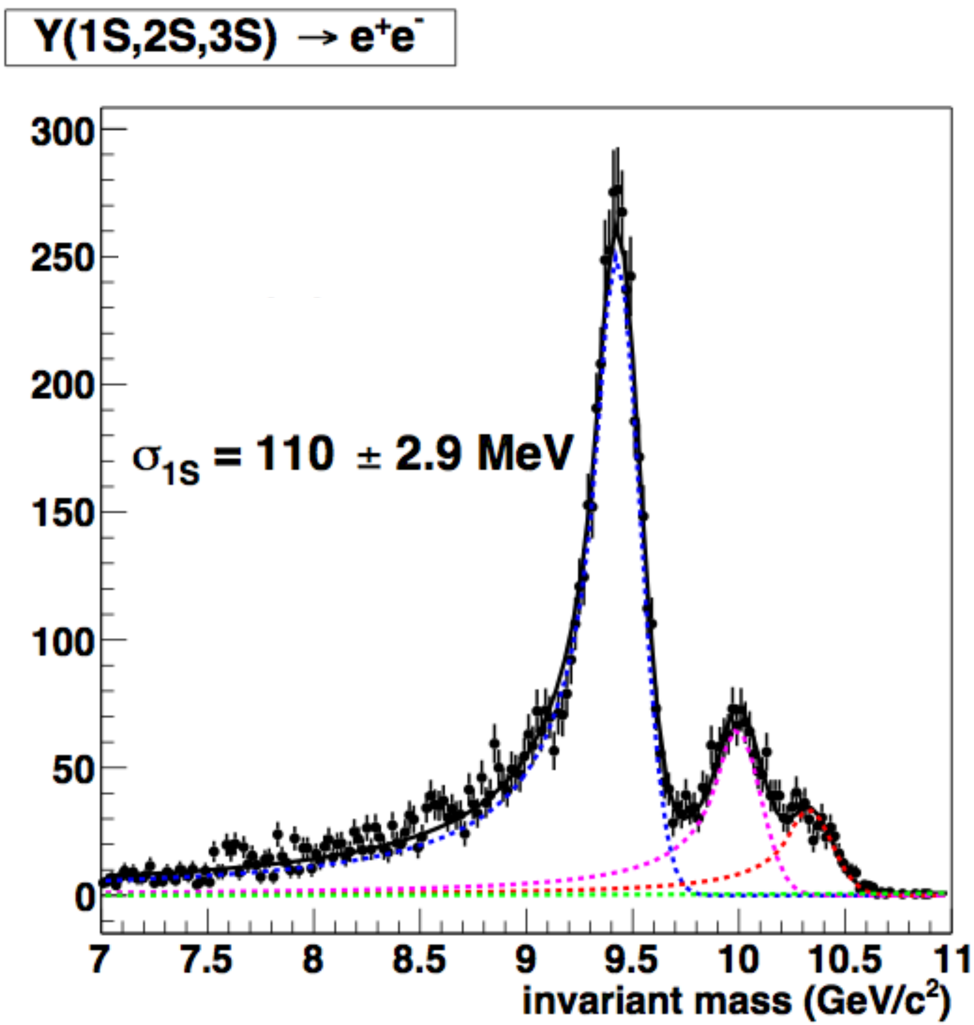
Strip size of the strip detector

80um x 12mm

Outer tracker is implemented as strip detector with 250um x 12mm strip

- The three upsilon states are clearly separated
- The simulation include the effect of internal bremsstrahlung, which causes about half of the radiative tail.
- The minim model has sufficient performace for single upsilon. 3 staes well separated

G4 Simulation: Upsilon embedded in central HIJING



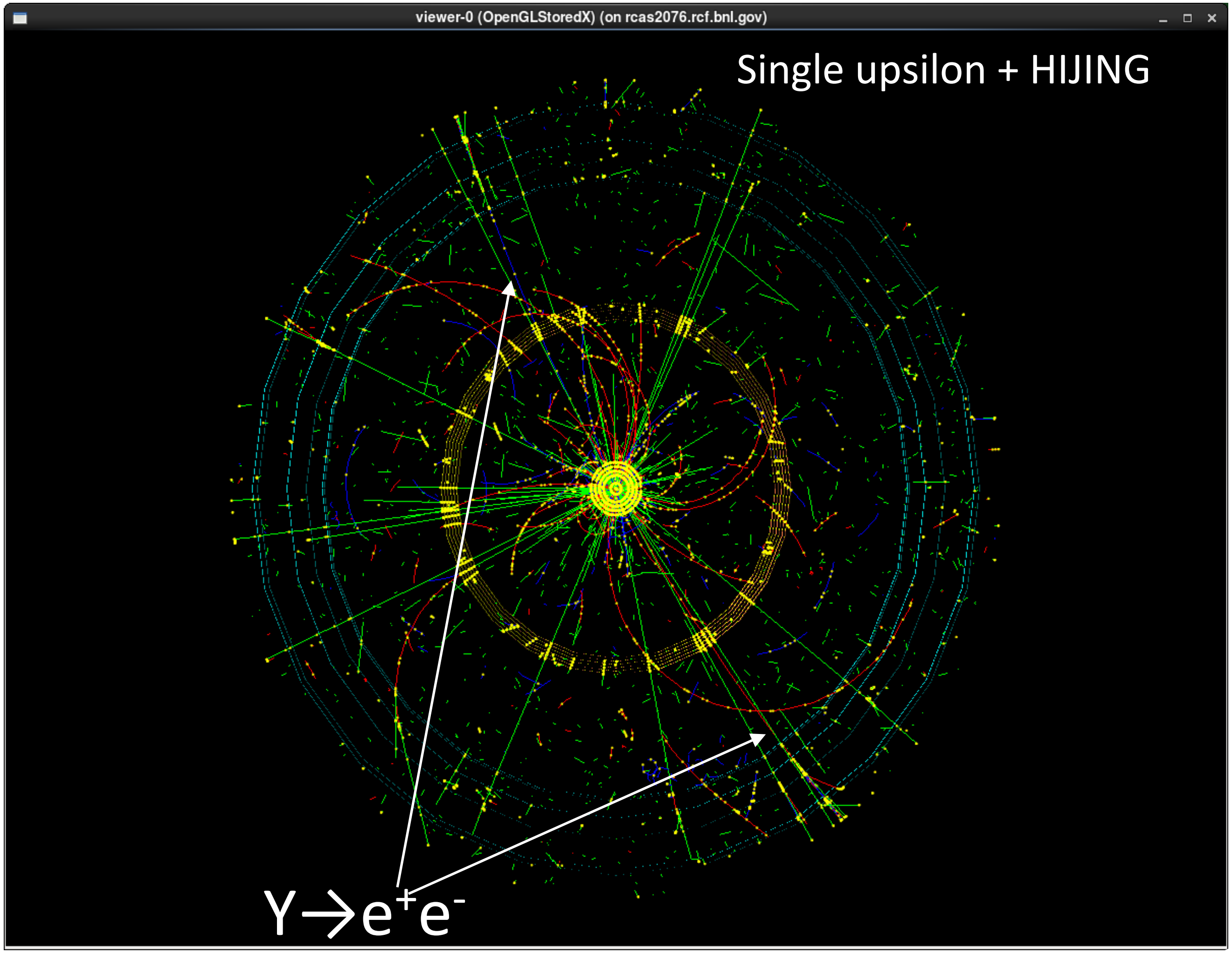
Single upsilon 1S/2S/3S with internal bremsstrahlung embedded in central HIJING and reconstructed.

The model of the tracker is the same as the previous slide

Upsilon mass resolution looks OK.

Part of the cause of the worse mass resolution than single upsilon case can be due to the limitation of the current reconstruction code and can be improved.

Event display (Upsilon in central Hijing)

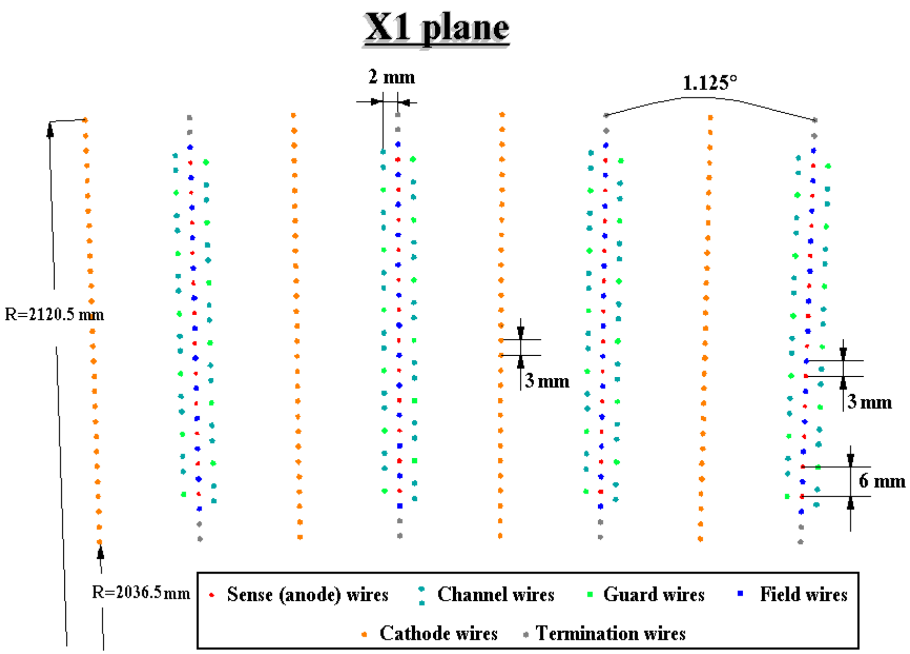


(slice at |dz| < 0.5 cm)

What is demonstrated by the simulaiton

- The simulation results in the previous page demonstrated that
  - If 1 pixel + 4 strip can reconstruct a track and its track can be associated with a thin outer tracker in front of EMCAL. This detector combination can separate the 3 Upsilon states in central Au+Au collisions
  - We believe that the outer tracker can be a Drift chamber like the PHENIX DC
  - Due to the limitation of the current G4 reconstruction program, the length of “tracker strip” was only 12mm. We believe that much longer strip spanning Z>0 and Z<0 can also work in central HIJING event if we have appropriate reconstruction code.
    - This point need to be confirmed by a full simulation

A Concept of the outer tracker

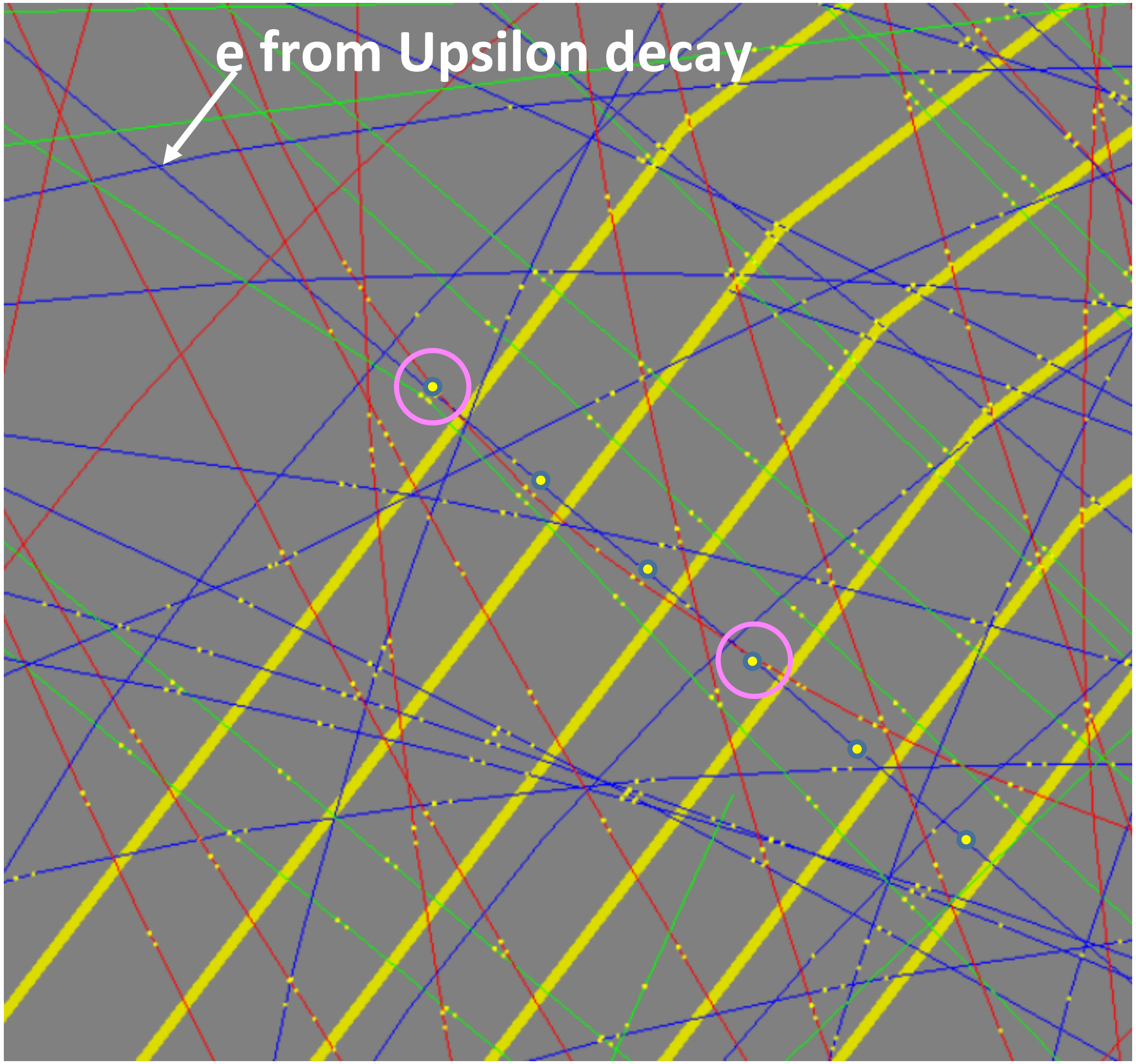


- A possible outer tracker is a Drift chamber that is similar to X1 section of PHEINX DC
- Key parameters
  - Max Drift length: 2cm
  - 12 anode (6 Left, 6 right)
  - Gate/back wire to solve left/right separation
  - 2 track separation better than 1mm
  - An anode is separated at the middle and Z>0 and Z<0 is read-out separately (same as PHENIX DC)

DC structure (continued)

- If the maximum drift distance is 2cm, the DC has 128 drift cells to cover 2 pi.
- Each cell has 12 wires, 6 for the left and 6 for the right (same as X1 or X2 section of PHENIX DC). Total of 1526 wires or 3072 read-out channels. It is about 1/8 of PHENIX DC (12800 ch)
- Each channel is read-out by 8bit 200 MHz Flash ADC
  - Time sampling 5nsec –>250 um
  - With appropriate shaping time, 2 track resolution better than 1mm should be possible.
  - PHENIX DC don't have FADC read-out. Its 2 track separation is 1.5mm
- The cost of making the DC should be much smaller than TPC with 200K channels

Hits in the DC (G4 simulation)



- All hits in Z>0 are integrated in this plot
- 2 of 6 hits of Upsilon electron can be merged with background track, but other 4 points are separated
- This means that this track can be reconstructed with an appropriate software

Plan to do

1) Make a realistic simulation of DC. Here we assume 1mm two track separation, which we believe technically achievable given that the present PHENIX DC have two track separation of 1.5mm without FADC readout. For this purpose, Gaku is developing a tracking code of projective geometry in the DC. The code will use the hit position of EMCAL as seed for the track. It will take a few weeks to develop the code.

Once the code is developed, we can evaluate what is the required detector performance of the DC and how many wires we need to achieve sufficient track reconstruction efficiency and low fake rate, etc.

2) Start the conceptual design of the DC. We assume that we can achieve 1mm two track resolution, but it is not trivial to achieve this level of two track separation. There are many technical issues, like

- Effect of Lorentz angle
- choice of gas (diffusion, drift speed, Lorentz angle, etc)
- sampling frequency of the FADC
- The wire arrangement to limit the electric field lines (Garfield calculation)
- Maximum drfit length (Is 4cm too long? We can reduce it)

Etc

Sophistication of Tracking Algorism in the Simulation (by Gaku)

- Implement EMCal hit position behind the DC and be used for tracking in both eta and phi dimensions.
- Utilize energy deposit information in the EMCal to limit the hit search space in p_T.
- Select hits in PIXEL, Strip, DC which meet above constraints and execute fit.
- Remove fakes by chi-2.

BACKUP

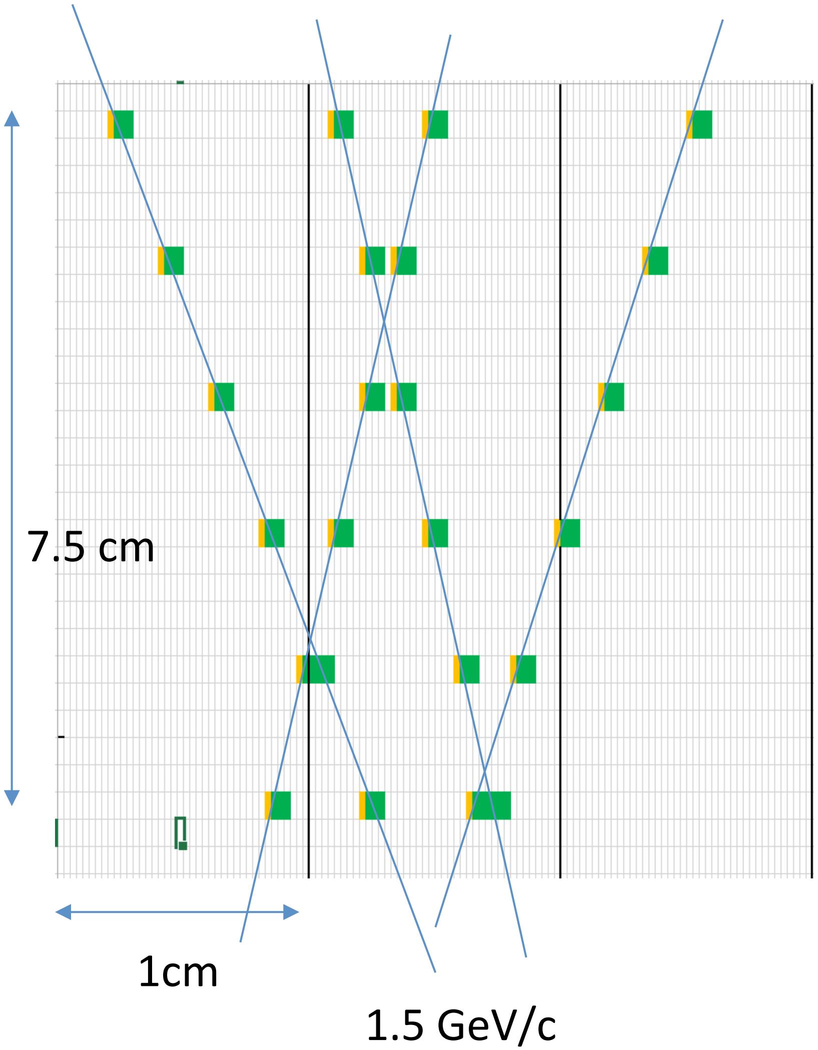
To Do

- We need to demonstrate the DC actually works in the central AuAu environment in full G4 simulation.
  - Need to develop a reconstruction code for this purpose. This is a must before the tracker review
- Once the code is developed, we can evaluate and optimize the detector configuration
- Once DC works in the simulation, we can further develop the actual configuration for the DC
  - Choice of gas
  - Effect of Lorenz angle
  - Mechanical consideration
  - Read out scheme (200MHz FADC is sufficient?)

To Do

- For inner strip detector, we need to further develop the detector concept and continue R and D
  - We have already made a larger S1 sensor and is making HDI for S1 sensor. We are to built S1 sensor module and test it
  - Develop the conceptual design of the compact innter tracker (R=6,8,10,12cm)
  - Design new S0 sensor (12cm x 2 cm) for the compact inner tracker described in the slide 11
  - Design new HDI and sensor module for the S1

How a central event in DC should look



- At R=80cm, the average spacing between a track in $\Delta\eta=1$ is 1cm. So one central AuAu event in a small part of DC should look like the figure on the left. Here I draw 4 lines in 3 cm. The dot in the plot represent 1mm width where two charge cannot be separated.
- I think there should no problem to reconstruct track.
- The momentum of the track can be read from the angle of the track. So one can easily select high pT track and associate it with the high energy EMC hit.
- All tracks in the left cartoon are in 1.5GeV/c ~ 2.4 GeV/c. So this is very unusual event. Most of the tracks are <1 GeV/c and can be discarded as low pT track when associated with a high energy EMC hit.